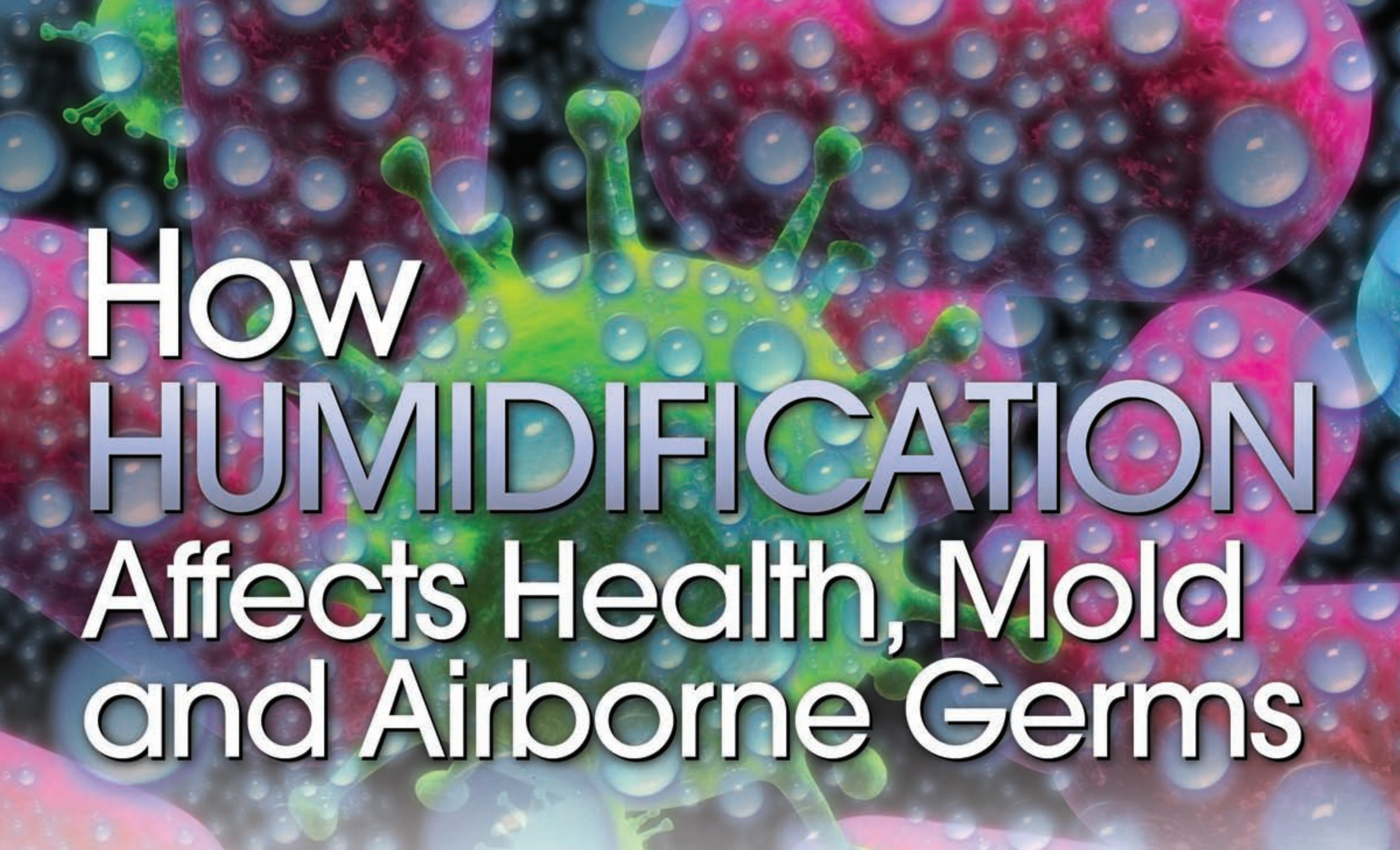

How HUMIDIFICATION Affects Health, Mold and Airborne Germs

If you were a mold spore, your mantra might be, "Surface moisture: can live with it, can't live without it." If you were a bacteria or virus, it would be just the opposite — they love low-humidity ambient conditions. Read on for insights into condensate prevention on cooler surfaces, hospital humidification standards here and abroad, and avoiding a recipe for mold soup.

BY STEVEN WELTY, LEED® AP, CIE, CAFS

The double edge sword dilemma: on one edge mechanical engineers (ME) must add airborne humidity into dry, low-grain air, which, here in Washington, happens during wintertime conditions. Sliding down that other edge, too much airborne humidity means that cooler surfaces can dewpoint out condensate moisture. $H_2 0$ molecules can drop out of the airstream and wet duct insulation surfaces promoting mold and bacteria (M&B) growth. Too much positive pressure can push humidity into wall cavities allowing M&B to grow. MEs must control both airborne humidity and building pressurization in order to reduce the resulting surface moisture, which helps create "mold soup."

WHAT IS THIS 'MOLD SOUP' OF WHICH YOU SPEAK?

Understanding how airborne mold spores land and grow into visible black, pink, or green fuzzy masses starts with the proper conditions allowing them to grow. Every mold species has its own ideal conditions under which it can grow the fastest. These are a combination of temperature, surface moisture, available water activity (Aw), and mold food. Understanding the conditions that allow mold to drive up to the soup kitchen and be handed its free meal is the critical first step.

I'm labeling the surface conditions that a mold spore requires in order to hatch and grow as mold soup. Without a mold soup surface, an airborne mold spore just lands on a surface and waits. And waits. Since mold is the most patient creature in the world, he'll hang around for thousands of years in this dormant state just waiting for the mold soup kitchen to open for business.

It's speculation that when archaeologists were breathing inside ancient tombs, their breath provided enough moisture for ancient dormant mold to wake back up and start launching the airborne egg spores (your exhaled breath is nearly 100% humidified). These newly wakened ancient molds may have popped off some nasty airborne spores laden with toxic chemicals (known as mycotoxins), which ended up killing some of the unsuspecting archeologists. The best picture of mold spores being launched is in the *Humidity Control Design Guide*[1] by Lew Harriman et al. on page 100.

While the built environment isn't as sexy as King Tut's burial chamber, one job an ME can do is to deny mold its soup. This allows you to say to the mold spore, "No soup for you!" which then becomes the battle cry in "mold wars."

MY MOLD SOUP RECIPE

While I've spent years perfecting it, the *ES* editors have convinced me to hand over my secret mold soup recipe. The critical ingredients are actually rather simple: you first ladle water onto any surface. Porous surfaces are excellent for soaking up water. Then a mold spore lands on it, hatches, grows, makes it darker, and then smells up the air. The

	ASHRAE	Japan Human-Winter	Japan Human-Summer
Emergency room	70° to 75°, 30% to 60% rh	22° to 26°, 40% to 50% rh	23° to 26°, 45% to 60% rh
Operating room	68° to 75°, 30% to 60% rh	22° to 26°, 40% to 50% rh	23° to 26°, 45 % to 60% rh
Patient's room	70° to 75°, 30% to 60% rh	22° to 24°, 40% to 50% rh	24° to 27°, 50% to 60% rh
Exam room	70° to 75°, 30% to 60% rh	22° to 24°, 40% to 50% rh	26° to 27°, 50% to 60% rh
Waiting room	70° to 75°, 30% to 60% rh	22° to 24°, 40% to 50% rh	26° to 27°, 50% to 60% rh

TABLE 1. ASHRAE and Japan Human & Society recommended hospital temperature and relative humidity values.

darkening and smell are clear proof that you've got mold growth. If you've smelled a stinky darkened sponge, then you've just dosed yourself with mold's volatile organic compounds (VOCs), which is the musty basement smell you may have experienced. Spores can be coated with mycotoxins (mold toxin) and the expression "toxic mold" derives from the word mycotoxin.

Next, add any carbon based material — cellulose tastes the best — which is found in paper and wood, but lesser known tasty ingredients like skin cells, paper, rug and clothing fibers will be suitable gourmet food for your local mold pals. That's my insider secret recipe for mold soup: airborne ingredients like skin cells and fibers are the invisible ingredients for tasty mold soup (that any mold spore would love to chow on). Mold can grow on any surface a long as there is available water that can trap airborne skin cells and fibers.

HOW MOLD GROWS ON CERAMIC TILES OR METAL

Tiles and metal are not organic (carbon-based) and therefore have no available mold grub. Yet everyone has seen mold on metal and tile surfaces, so how did that happen? When ceramic tile or metal dewpoints out surface condensation, sprinkling it with your airborne skin cells (you shed 1 to 10 million a day) along with fibers and bam! You've just whipped up a batch of tasty mold soup. Depending on your filtration efficiency and sterilization strength, there are billions to quadrillions of mold spores coursing around a building. The odds are nearly 100% that some will run smack into the surface mold soup. Moisture also increases surface friction to trap airborne spores and bacteria, thereby sparking their growth. Lower ambient temperatures can inhibit growth but you'd have to lower it to below 40° in order to affect most indoor mold growth (which is why refrigerators were invented).

HUMIDITY AND AIRBORNE HOSPITAL INFECTIONS

Hospitals have critical environments where humidity can significantly affect airborne virus and bacteria transmission. Last month in *ES* ("Save Lives, Become a Mechanical Engineer," January 2010, page 57), I detailed how the influenza virus survives and stays airborne longer in lower humidity/grains of moisture conditions. Wintertime indoor air having 35 to 45 grains or lower probably creates but at least exacerbates our annual flu season.

Norovirus likes low grain conditions, which was christened "winter vomiting disease" by the doctor who first described it in 1932. He had no idea about low grain viral transmission rates increasing in the wintertime. Viruses can stay airborne indefinitely by surfing on air currents until they impale a surface or you suck them into your nose, throat and lungs.

Airborne bacteria survival is also affected by the humidity/grains of moisture. The most prevalent airborne bacteria are staphylococcus and its more lethal version of MRSA. The science on airborne bacteria[2-4] suggests that it has lower survival rate in 45% to 55% humidity at 70° conditions. Forty-five percent rh at 70° is nearly 50 grains of moisture, which is also in my low transmission zone for viruses. (*ES*, January 2010) At 70° and 55% rh you have a whopping 60 grains of moisture, which puts you in the low to no bacteria transmission zone, also reflecting the low to no viral transmission zone.

AIRBORNE HUMIDITY BEGETS SURFACE HUMIDITY

Mold doesn't grow in the air and can therefore only grow on surfaces. That's why I care little what the rh is in the middle of a room. Just because you have 55% rh in the air does not mean that you have 55% rh on the surfaces. In my IAQ investigations, I take surface rh readings, which can be 5% to 15% higher than ambient room conditions depending on the porosity of the surfaces I'm testing.

LIGHTEN UP YOUR PRESSURE

Dialing in the correct building pressurization is critical because overly positively pressurized buildings have the potential to drive humidity into porous surfaces. This is the cutting edge of the humidity sword. I agree with Harriman that in the wintertime having a neutral or ever so slightly negatively pressurized (1 to 2 Pascals) building is a great strategy in order to help prevent humidity from being forced into your porous surfaces thereby creating mold soup conditions.

ADIABATIC AND ISOTHERMAL HUMIDIFICATION

Adiabatic humidifiers can atomize moisture or flow it over media. Adiabatic humidifiers use nozzles, ultrasonic, and centrifugal atomizers. Isothermal humidifiers use steam to produce humidity. Steam is better at creating humidity as more of it turns into

humidity without droplets falling out of the airstream like in atomizing adiabatic systems.

LIQUID DESICCANT HUMIDIFICATION

Liquid desiccant (LD) systems use lithium chloride (LiCl) that flows through a medium, which exposes it to the airstream. That medium is sandwiched between membranes to prevent downstream transfer of LiCl into the airstream. It uses vapor pressure to add humidity directly to the air. There's another system on the exhaust air to capture sensible energy needed to regenerate the LD. The huge benefit of LD is that a single pass can add enough grains of moisture to easily hit 55 grains (70°, 50% rh) even if you have only 7 grains air outdoors (30°, 30% rh). This creates low survival and transmission conditions for airborne viruses and bacteria. One liquid desiccant manufacturer claims that the bactericidal, virucidal, and fungicidal qualities of lithium chloride can kill up to 94% of the bacteria, mold and viruses passing through it. Chapter 21 "Humidifiers" in the *2008 ASHRAE Handbook — HVAC Systems and Equipment* is a well-written guide to each of these systems.

HEALTH AFFECTS OF THESE SYSTEMS

Adiabatic atomizing systems can create airborne minerals when improperly filtered water evaporates and sheds them into the air. Breathing in airborne minerals is never good. Mold and bacteria (M&B) problems can grow in exposed reservoirs unless they are properly sterilized as standing water provides a moisture source allowing M&B growth.

These growing M&B can then be:

- Aerosolized by the HVAC airflow
- Transported through the downstream ductwork
- Spewed into occupied spaces

This mimics the M&B infestation that occurs within condensate drain pans and cooling coils, which is another reason why they also need to be sterilized 24/7/365 in order to prevent M&B aerosolization.

Steam systems are healthier than adiabatic because steam is distilled water (no minerals). Steam tends to have more individual H_2O molecules, which is healthier as they tend to not plate out in the downstream ductwork, which is another weakness of adiabatic aerosolization systems.

LD systems are the healthiest as LiCl is a natural fungicide, bactericide, and virucide. Another health benefit of an LD system is that it easily provides precise humidification, which in wintertime is critical for airborne virus protection.

U.S. AND JAPANESE HOSPITAL HUMIDITY STANDARDS

ASHRAE's *HVAC Design Manual for Hospitals and Clinics*[5] provides a list of recommended temperature and humidity levels for hospitals. In Japan there is a list of recommended hospital humidity and temperature levels promulgated by the Human and Society Environment Science Laboratory[6]. Their recommendations are much narrower than ASHRAE and they also have summer and winter values, which recognize the challenges of wintertime humidification and summer dehumidification using adiabatic or isothermal systems.

I like the human wintertime values for airborne virus and bacteria transmission control as it recommends higher minimum humidity levels of 45% rh vs 30% rh (ASHRAE). Higher grains significantly reduce the both the transmission and viability of these germs.

For airborne infection control, I've never liked any ambient indoor rh below 40% as that's the crossover point where survival and transmission of airborne viruses and bacteria increase exponentially. I also don't like the human summer values with 60% rh as a setpoint because the actual room rh may drift to 65% to 70%, which can drive surface humidity moisture to 70% to 85% thereby creating ideal mold growth conditions. Dial in an overly positively pressurized building and you'll drive that moisture into the walls creating mold soup conditions. Eventually that moisture will push through into the spaces behind the walls creating more opportunities for mold growth.

Managing the humidity/grains of moisture along with building pressurization, especially in hospitals, is critical in preventing airborne viruses and bacteria from making occupants ill. It's also critical to prevent mold growth on and behind interior surfaces. MEs need to dial in the correct humidity/grains of moisture along with pressurization, which can be a matter of life and death to susceptible and immune compromised occupants. It also affects occupants who have asthma and allergies along with children who are even more susceptible to airborne germs. Once again, MEs can save lives and make people healthier. **ES**

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